

## **Phase 2 Project Summary**

Firm: Streamline Automation, LLC

Contract Number: NNX10CB13C

Project Title: Compact, Controlled Force Crew Exercise System

Spaceflight leads to muscle and bone atrophy, and isoinertial (free-weight) exercises provide a sufficient stimulus to elicit increases in both muscle strength and bone mineral density in earth-based studies. While exercise equipment is in use on the International Space Station for crew member health maintenance, current devices are too large to place in a transport vehicle or small spacecraft. Therefore, a portable computer controlled resistance exercise device is being developed for NASA that is able to simulate the inertial loading experienced when lifting a mass on earth. This portable device weighs less than 50 lb and can simulate the resistance of lifting and lowering up to 600 lb of free-weights. The objective is to allow crew members to perform resistance exercise with loads that have been shown to be necessary to maintain muscle and bone health. The device is reconfigurable and allows for the performance of typical free-weight exercises. Forces exerted, volume of work, range of motion, time-under-tension, and speed/acceleration of movement are recorded and can be remotely monitored to track progress and modify individual protocols based on exercise session data.

Prototype system testing was performed at NASA-JSC with 9 human subjects over a 3 day period. The exercises performed were selected to work the major muscle groups that are targeted to maintain muscle mass and bone density. They included, for example, squat, deadlift, bench press, shoulder press, upright row, and bicep curl. Loads during testing ranged for a low of 4 N (~1 lbf) to 1600 N (~360 lbf).

The proposed exercise countermeasure could be used in virtually any aspect of NASA's current and proposed human spaceflight missions. Near-term application aboard the International Space Station could serve as an on-orbit trial for the system. Future NASA missions are expected to be of relatively long duration Mars missions that will involve extended stays, or asteroid rendezvous missions. These long term missions will require a resistance exercise system in order to enable the crew to maintain muscle mass and bone density.

Free weights are the gold standard for resistance exercise, but a sizable market has developed that revolves around alternatives to free weights. Spring-based systems are well known, but do not accurately simulate the lifting of free weights. Free weights and weight stack-based system tend require significant floor space. There is a market for a compact exercise system that can be easily stored, but that provides the benefits associated with free weights.

Stroke victims often experience muscle weakness and paralysis of one or both sides of the body. Intensive movement practice helps "rewire" the brain. More specifically, undamaged cortical areas can assume control functions that were previously allocated to damaged areas. Streamline Automation is pursuing the development a derivative controlled physical therapy system. It will be capable of providing motion assistance to guide the upper and lower-body limbs to help restore coordination, balance, and strength.

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